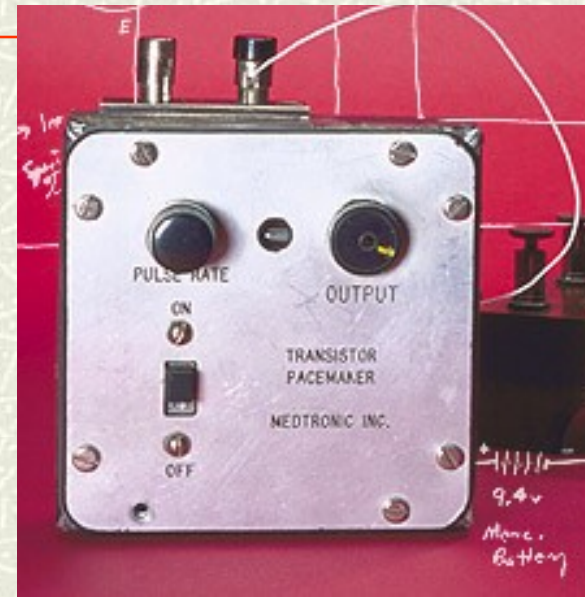


Pacemakers & ICDs

Christian Popa, MD



1st pacemaker 1957

**Earl Elmer Bakken, Founded Medtronic,
#111 on Forbes 500 in 2003**

"Back at the garage, I dug out a back issue of Popular Electronics magazine in which I recalled seeing a circuit for an electronic, transistorized metronome. The circuit transmitted clicks through a loudspeaker; the rate of the clicks could be adjusted to fit the music. I simply modified that circuit and placed it, without the loudspeaker, in a four-inch-square, inch-and-

Pop Quiz



Most modern internal pacemakers use (epicardial or endocardial) leads

How many letters in the pacemaker coding system and what do they mean ?

T or F- You should place a temporary transvenous pacemaker in a patient with LBBB while placing a PA catheter.

T or F- An asymptomatic patient with 3rd degree heart block and a HR of 38 should receive a permanent pacemaker.

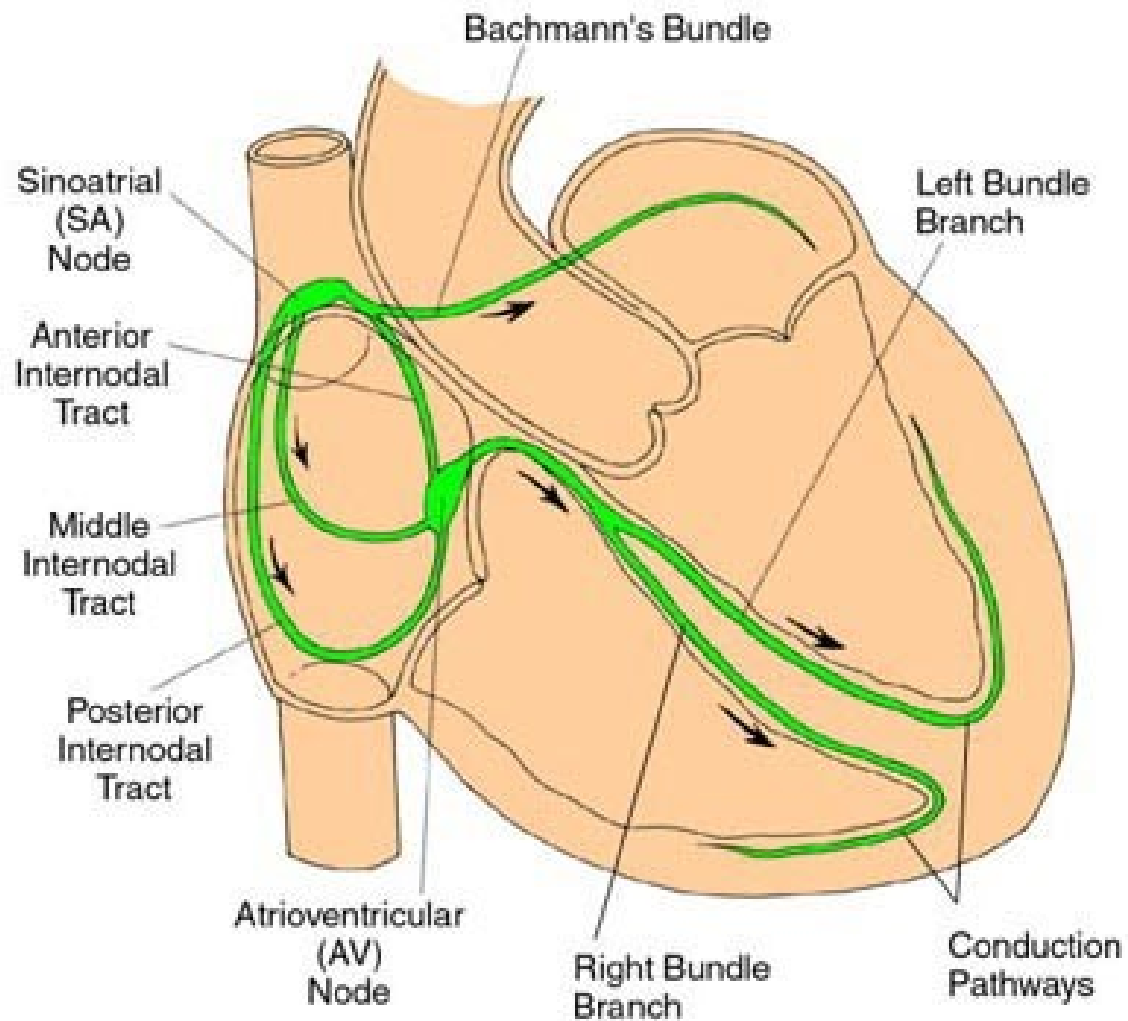
T or F - Temporary transvenous pacing is associated with a high complication rate.

What is the sensing threshold ?

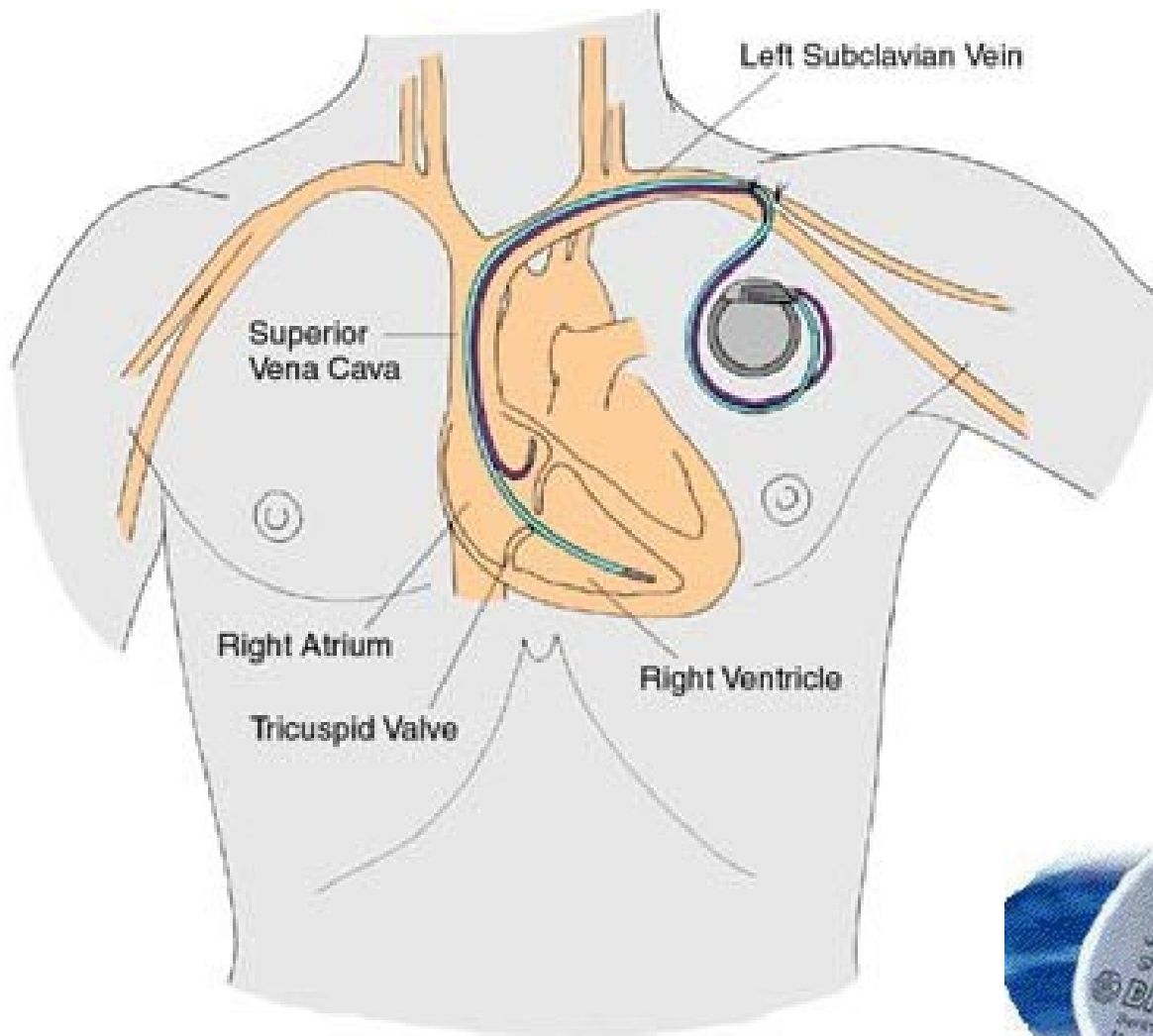
(a) What is the pacing threshold and (b) Name 3 metabolic abnormalities that affect the pacing threshold.

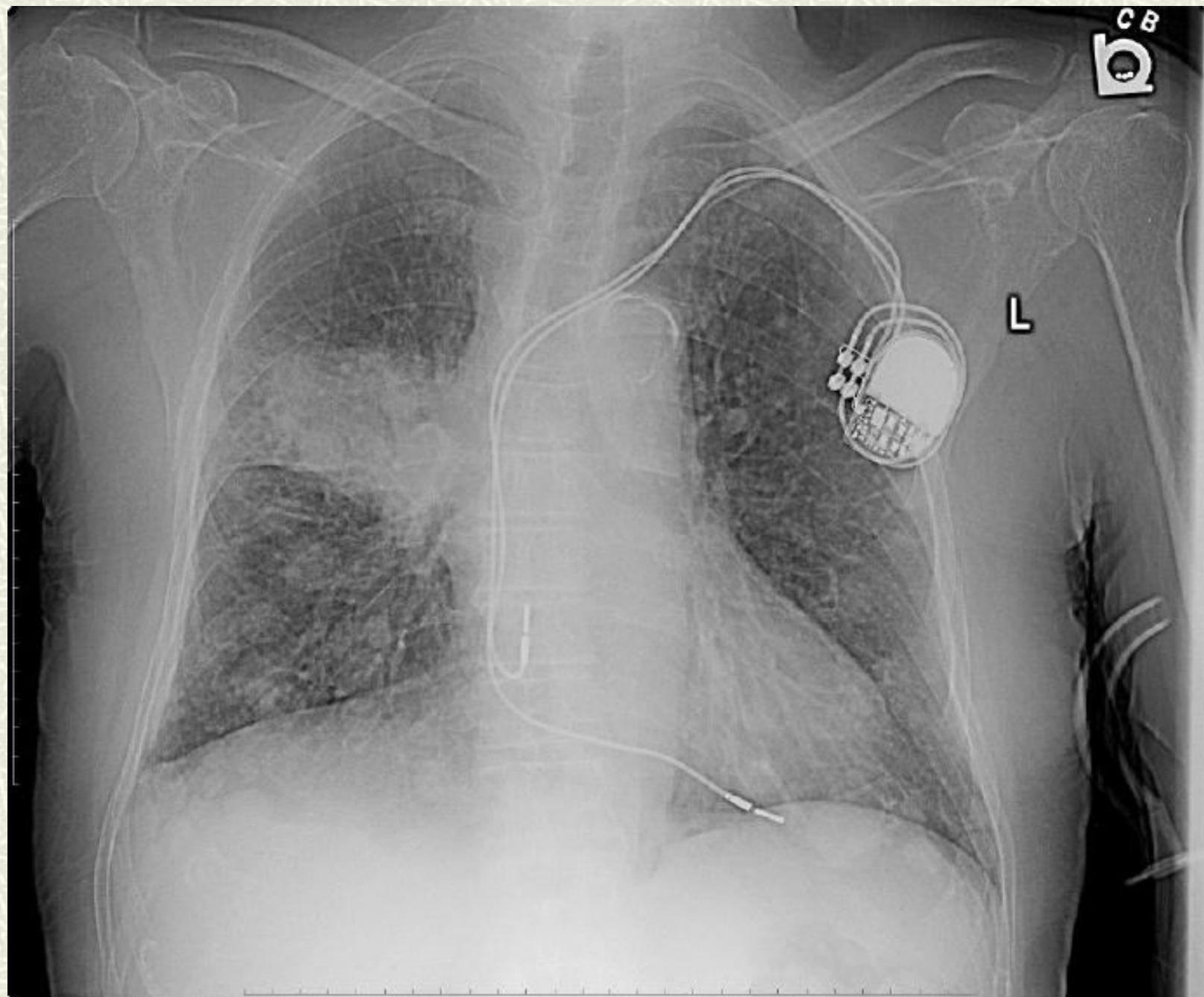
T or F- For surgery, DDD mode is preferable to DOO mode.

The Electrical System of the Heart



Dual-Chamber Pacemaker

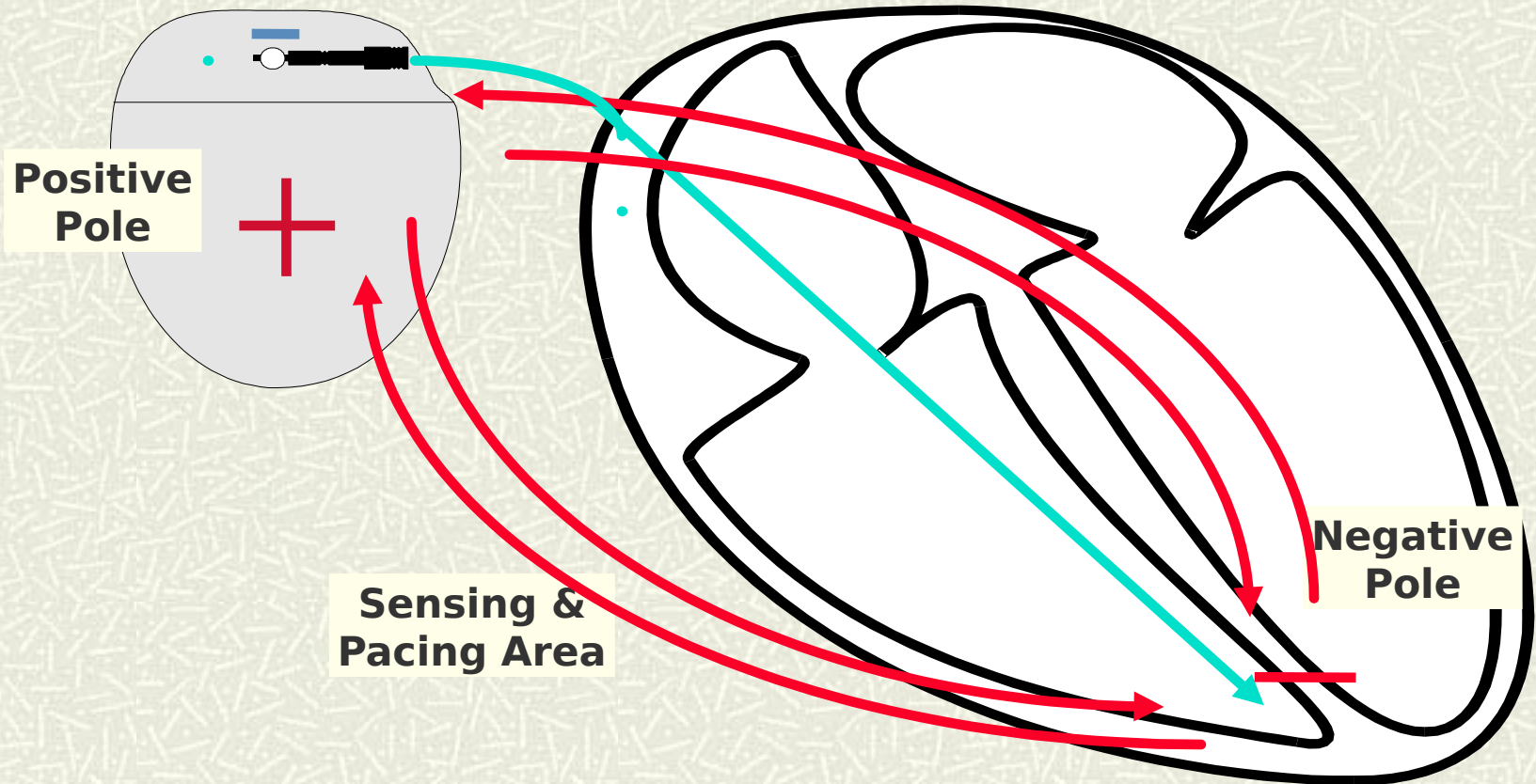






Unipolar versus Bipolar

Unipolar



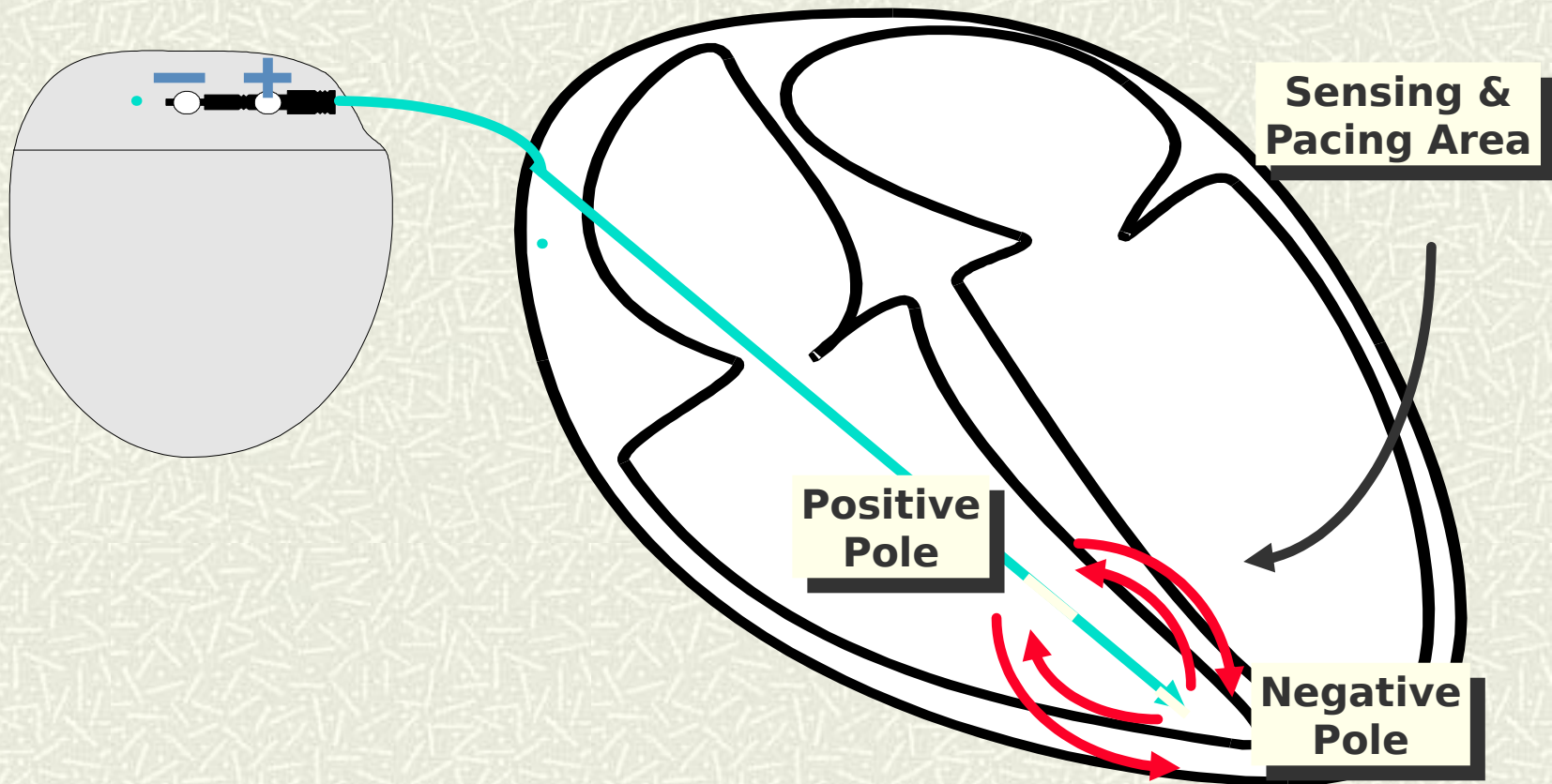
Unipolar Pacing

PROS: Unipolar sensing pacemakers *typically* have better intrinsic signal strength.

A large pacemaker artifact to aid in recognition of captured beats on monitoring equipment or the surface ECG.

CONS: Pocket stimulation.
Cannot be used with implantable defibrillators.
More susceptible to electromagnetic interference, myopotential sensing, and far-field sensing.

Bipolar





Bipolar Pacing

Pro: No pocket stimulation. Bipolar sensing is less susceptible to myopotential inhibition, electromagnetic interference, and far-field sensing.

- *If an implantable defibrillator and pacemaker are used in the same patient, the pacemaker should be programmed to the bipolar pacing configuration so double counting does not occur. The pacemaker must retain its bipolar polarity in its “back-up” mode.*

Con: Small pacemaker artifact on the surface ECG or monitoring equipment- *Unless the ECG equipment has digital enhancement*



Settings

Vent Rate (30-180)

Atrial Output 0 to 20 mA

Ventricular Output 0 to 20 mA

AV Interval 0 to 300 msec

Atrial and ventricular
sensitivity (1 to 10 mV)

The NASPE-BPEG pacemaker code

I	II	III	IV	V
Chamber Paced Antitachycardia	Chamber Sensed	Response to Sensed Event	Programmability	
Functions			Rate Response	
O (none) (none)	O (none)	O (none)	O (none)	O
A (atrium) (adaptive rate)	P (ATP)	A (atrium)	I (inhibit)	R
V (ventricle) (simple programmable)		V (ventricle) S (shock)	T (triggered)	P
D (dual; A + V) (dual; P + S)	D (dual; A + V)	D (I + T)	M (multiprogrammable)	D
S (single)	S (single)			C



Capture

The depolarization and resultant contraction of the Atria or Ventricles in response to an electrical stimulus emitted by a pacemaker.

One-to-one capture occurs when each electrical stimulus causes a corresponding depolarization and resultant cardiac contraction.



Sensing

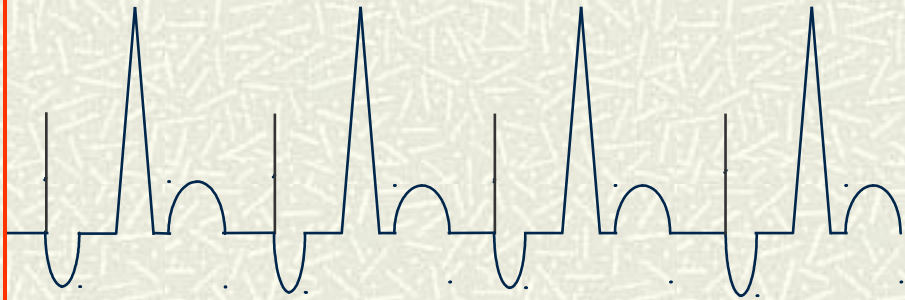
- ❖ Definition: The ability of the pacemaker to sense an intrinsic electrical signal. Sensing is dependent upon the amplitude, slew rate, and frequency of the signal.
- ❖ The sensitivity setting of the pacemaker indicates the minimum intracardiac signal required by the pacemaker to initiate the pacemaker response (inhibited or triggered).




Threshold

- ❖ Stimulation Threshold - The minimum amount of electrical energy that consistently produces a depolarization and resultant contraction.
 - can be expressed in terms of amplitude (milliamperes or volts), pulse duration (milliseconds), charge (microcoulombs), or energy (microjoules).

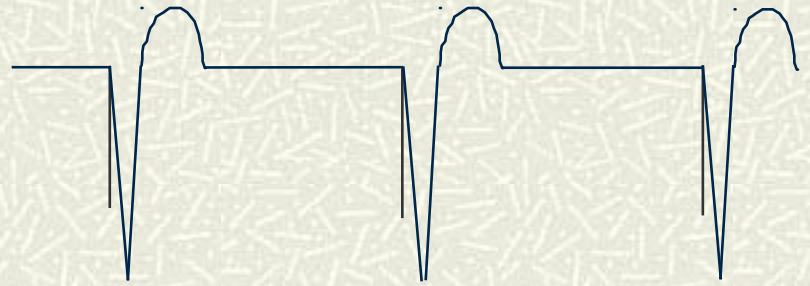
Atrial Capture



Ventricular Capture



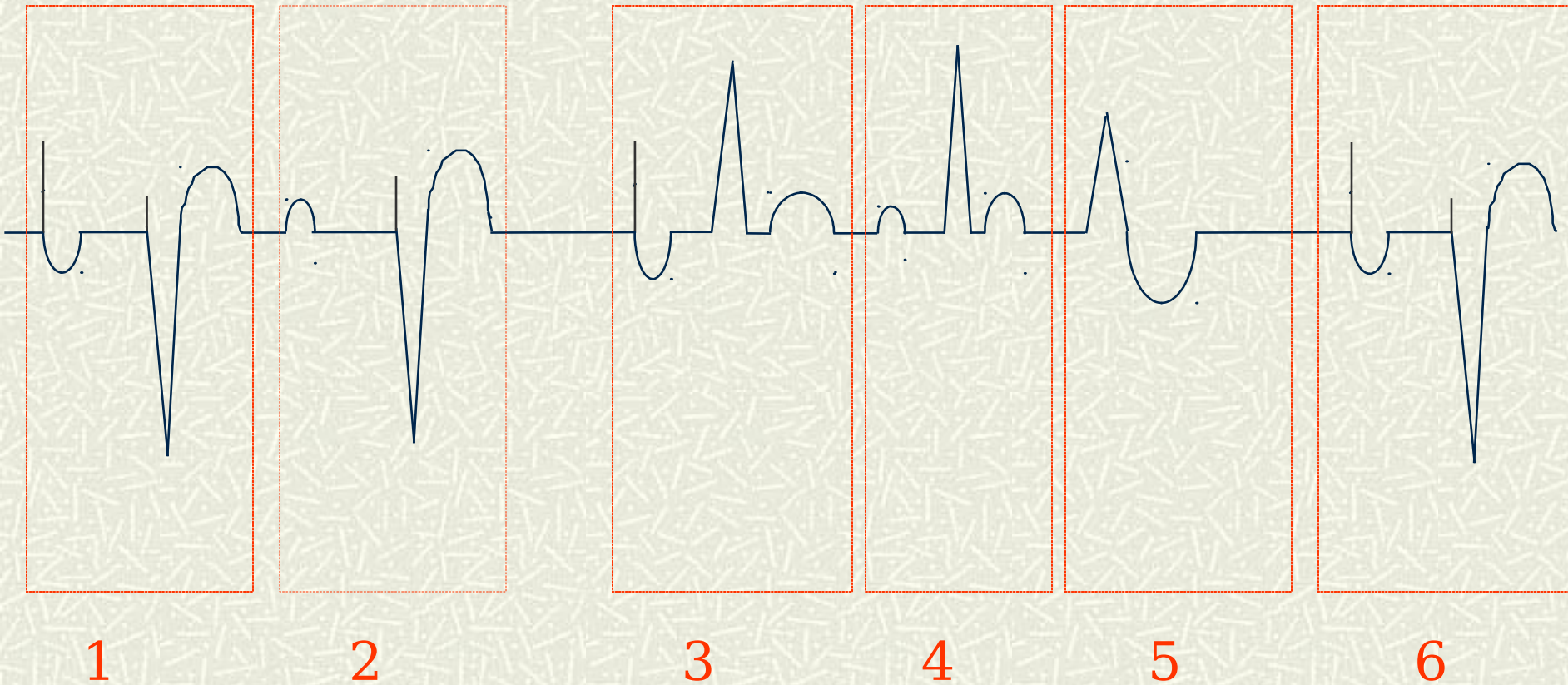
The ECG tracing displays three distinct cardiac cycles. Each cycle begins with a P wave, followed by a sharp, deep Q wave, then a tall, narrow R wave, and finally a T wave. The QRS complex is notably wider and taller than the P wave, which is characteristic of ventricular activation. The baseline is stable, and the rhythm appears regular.



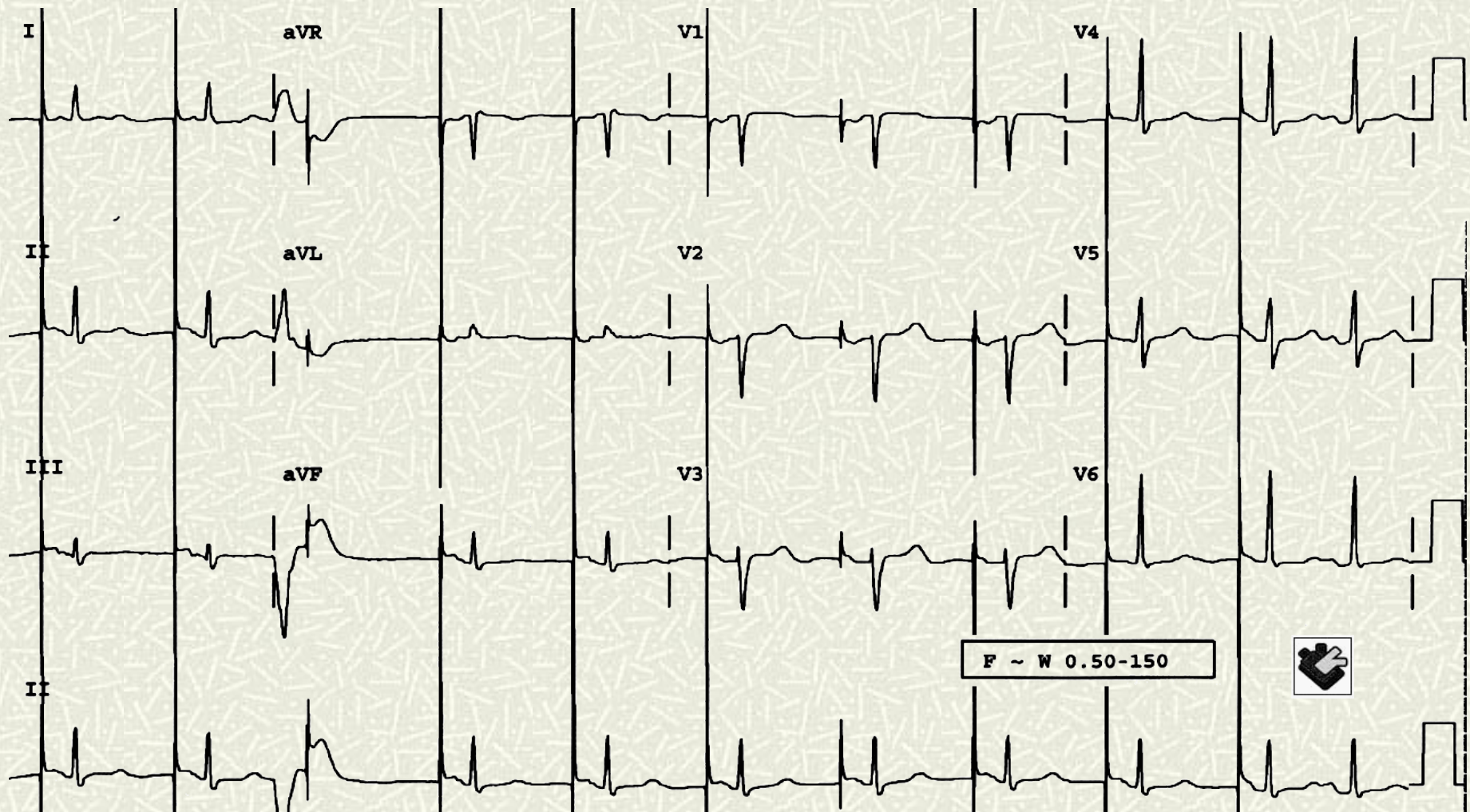
Atrial + ventricular Capture



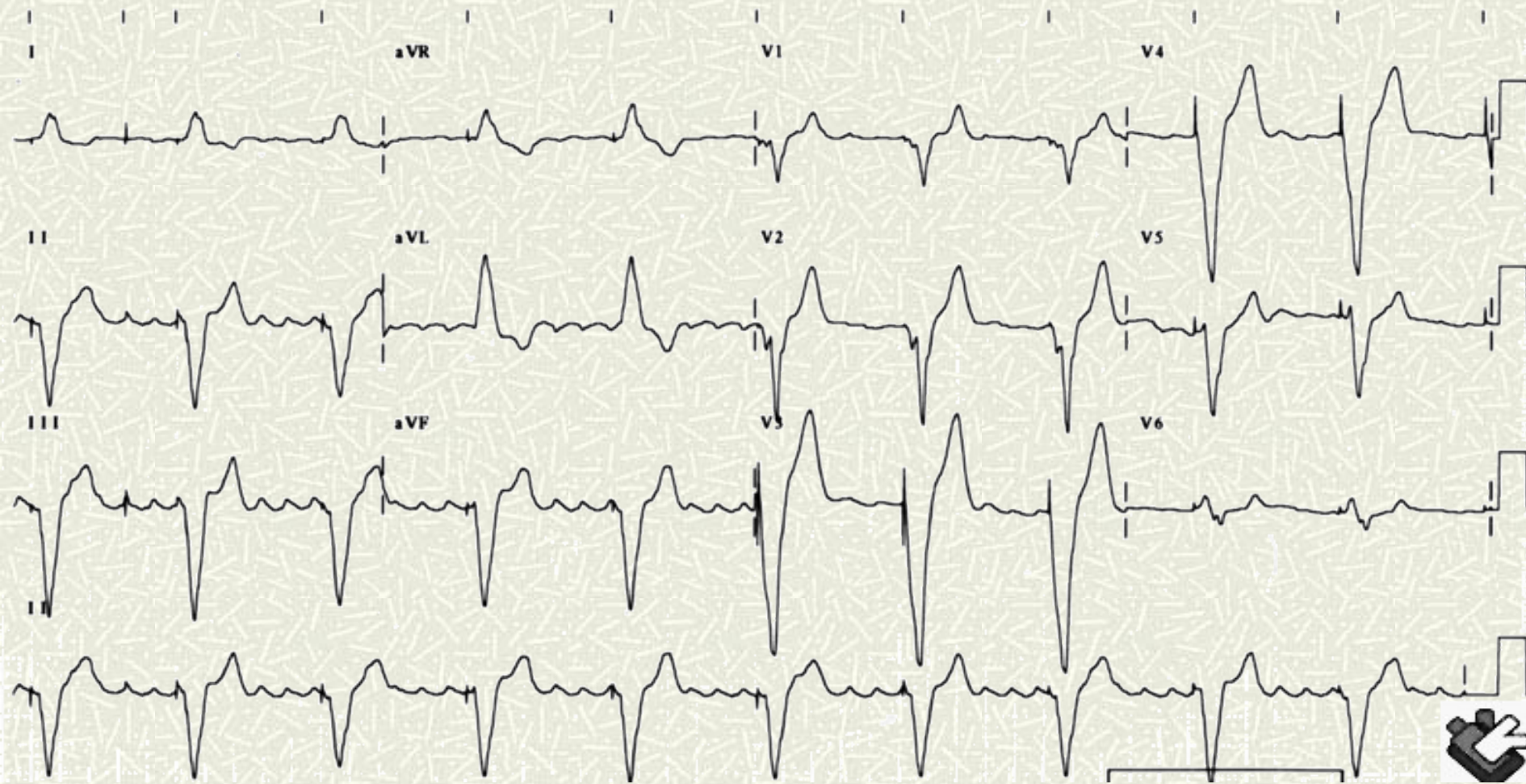
ECG Analysis



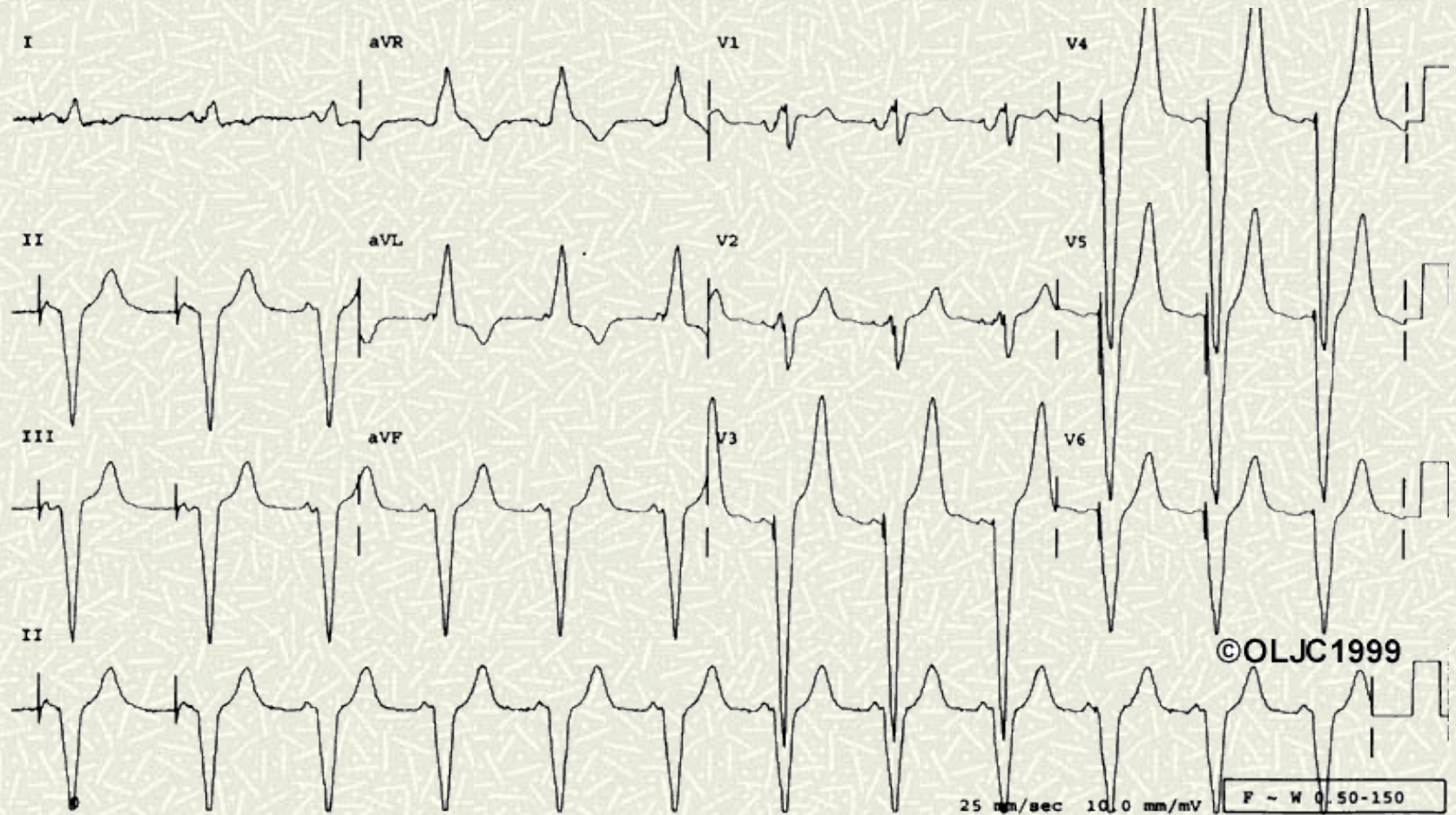
What type of pacer ?



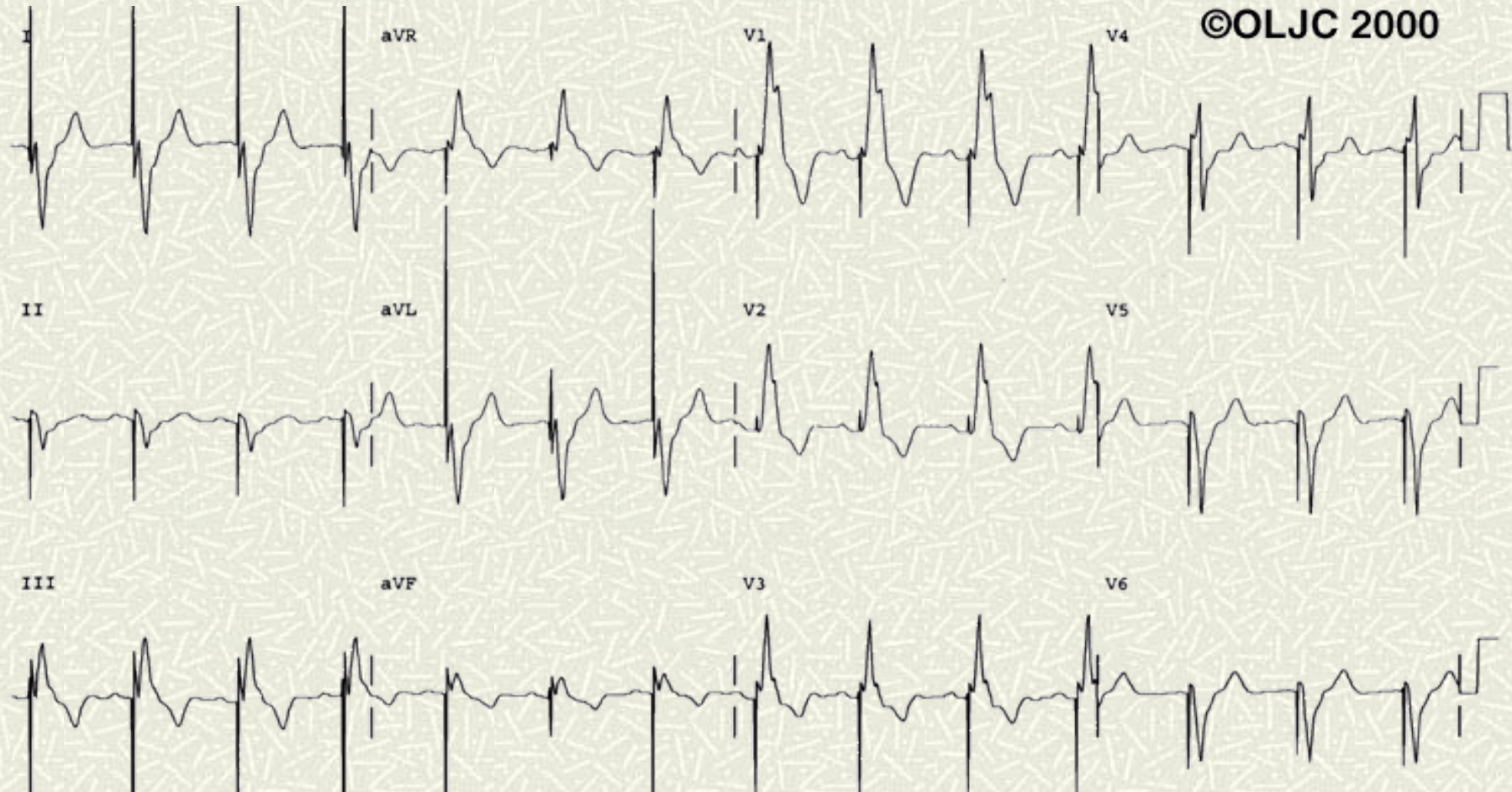
What type of pacer ?



What type of pacer ?



What's wrong with this picture ?



Class I Pacemaker Indications

3 ° AVHB AND

Symptomatic bradycardia or need for drugs causing same

After catheter ablation of AV junction

Postoperative

Neuromuscular disease

Escape rhythm < 40 bpm or asystole > 3 s in
ASYMPTOMATIC patient

Permanent / intermittent symptomatic type II 2 ° AVHB

Recurrent syncope caused by carotid sinus
hyperstimulation

During AMI- asystole, new RBBB or bifascicular block with 1°
AVHB, alternating BBB, or type II AVHB

Class II Pacemaker Indications

Asymptomatic 3 ° AVHB with rate > 40 bpm

Asymptomatic Type II 2 ° AVHB

Type I 2 ° AVHB below His bundle without symptoms

1 ° AVHB with symptoms of low cardiac output or CHF

BFB or TFB block with syncope not proven due to AVHB but with no other identifiable cause

SND with heart rates < 40

During PA catheter insertion in patients with LBBB

New RBBB or new BFB with AMI (no 1 ° AVHB)



Class III Pacemaker Indications

Asymptomatic 1 ° AVHB

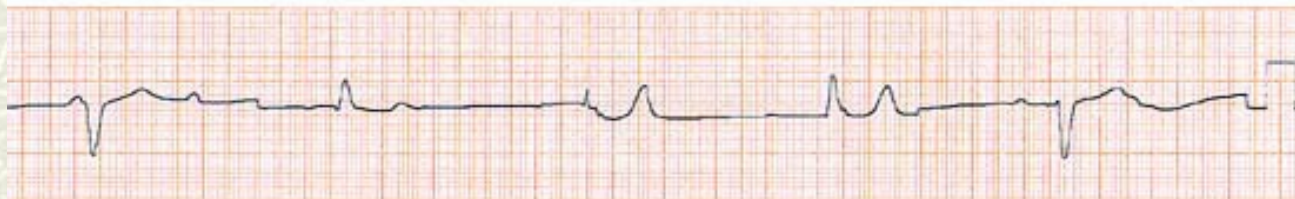
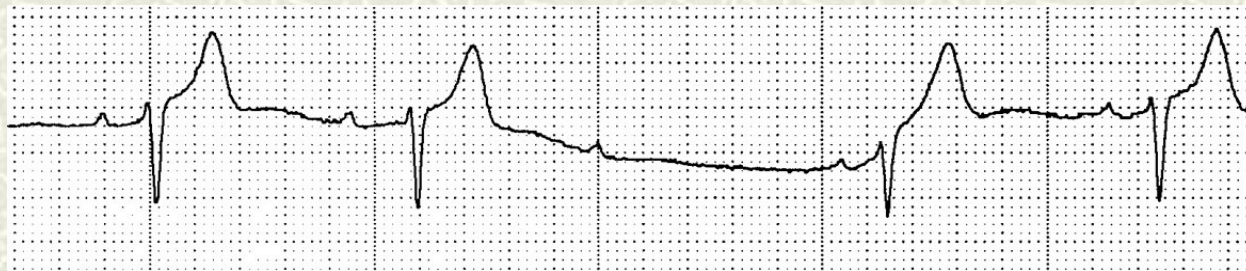
Asymptomatic Type I, 2 ° AVHB

AVHB that is expected to resolve

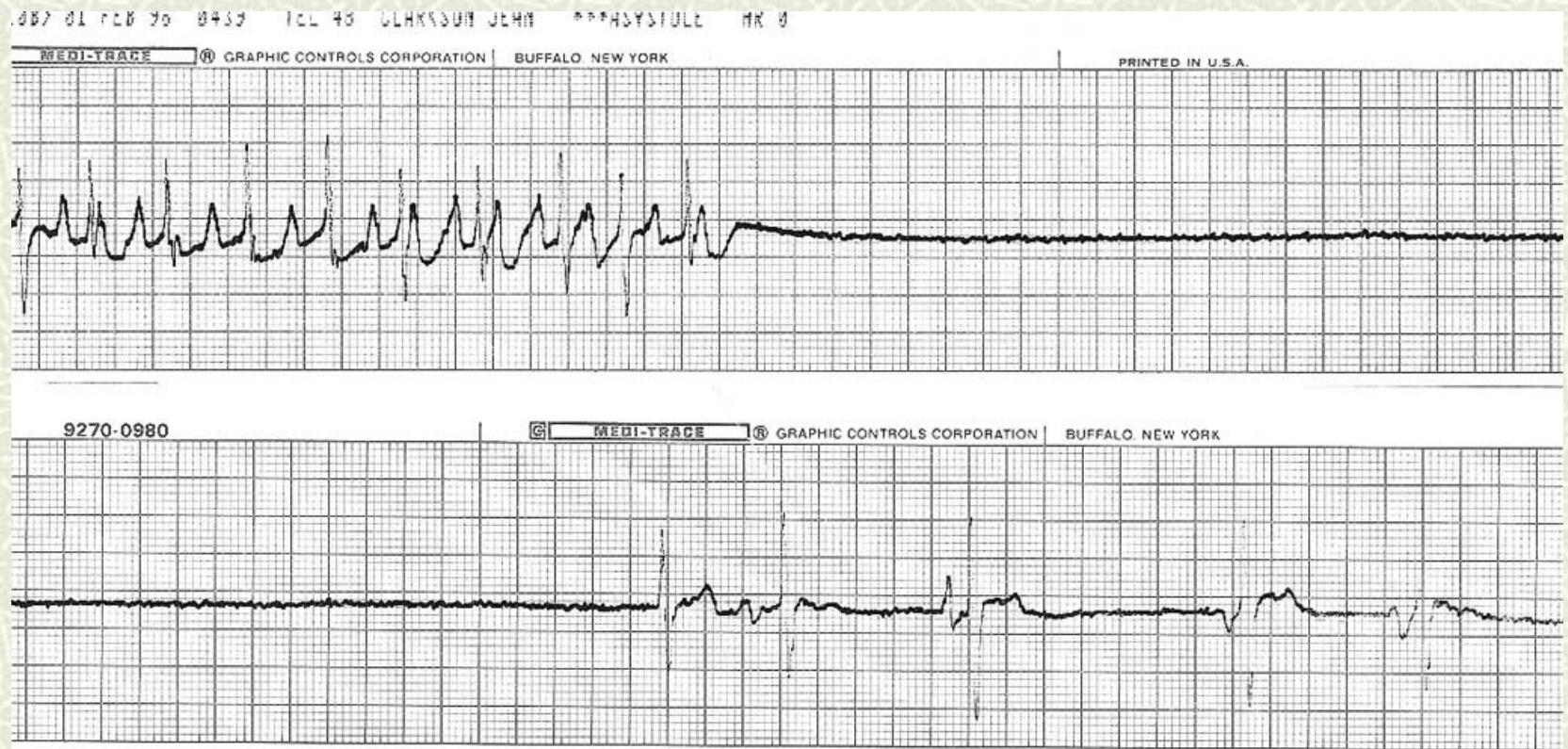
BFB or TFB without AVHB or symptoms

BFB or TFB with 1 ° AVHB without symptoms

Recurrent syncope in absence of hypersensitive carotid sinus response



What is this ?



Pacemaker Malfunction



❖ Failure to pace

Intrinsic cardiac depolarization

Oversensing

Broken, dislodged, disconnected leads

Impending battery depletion

❖ Failure to Capture

Fibrosis at lead-tissue interface

Drugs or conditions which ↑ pacing threshold

❖ Pacing at abnormal rates

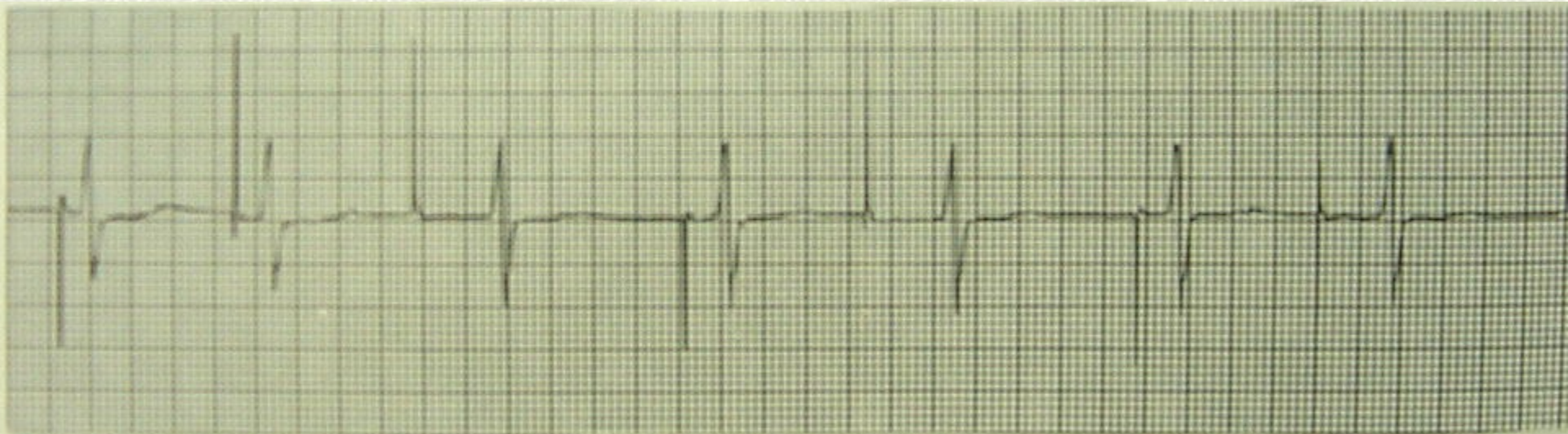
Oversensing

adaptive rate pacing

Crosstalk Inhibition with dual-chamber devices



What does this depict ?



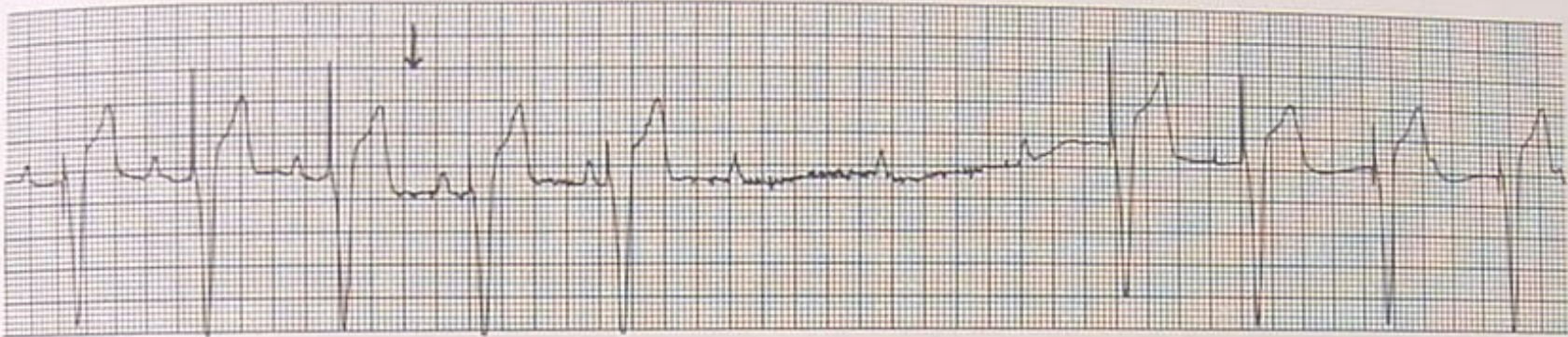


FIGURE 32-4 Myopotential inhibition of a unipolar permanent pacemaker. The pulse generator was placed next to the pectoral muscle, and inappropriate inhibition of the pacemaker

occurred whenever the patient adducted her arm. Forcible arm adduction begins at the arrow where muscular artifact can be discerned in the tracing.

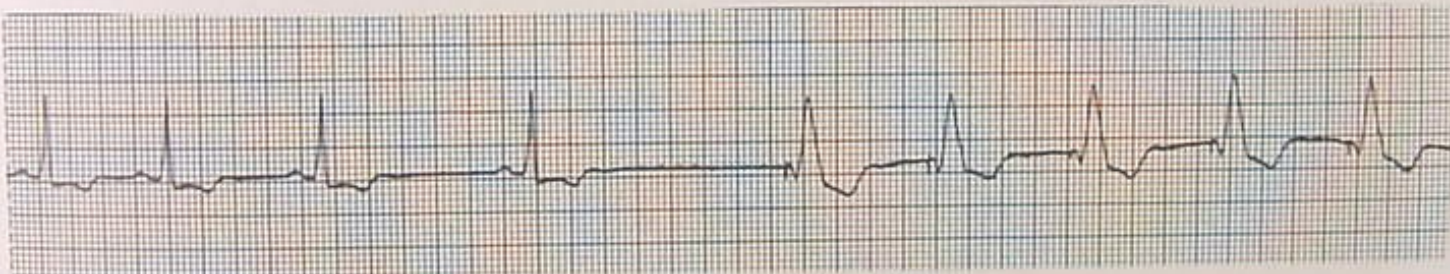


FIGURE 32-5 Pacemaker hysteresis. The pacemaker is programmed to pace at 70 pulses per min, but not to start pacing until the heart rate has fallen below 40 bpm.

Response of Pacemaker to Magnet

Most devices- Asynchronous pacing in SOO or DOO mode at programmed rate (Thera DR or D, Medtronic, 85 bpm)

With battery depletion, pacing at EOL indicator (Thera DR or D, Medtronic, 65 bpm)

Useful for malsensing, EMI

However- magnet response may have been programmed off, device may continue to pace asynchronously, or pacing will cease after a preprogrammed interval. Worst, EMI will open a programming circuit.

MOST ICDs- magnet will turn off sensing/shock delivery while magnet is in place.

Potential Sources of EMI

EMI Source	Generator		Complete		One-beat	
	Asynch	Rate	Inhibition	Inhibition		
Pacing	Damage	Increase				
Electrocautery	Yes	Yes	Yes	Yes	Yes	
External DCDF	Yes	No	No	Yes	Yes	
MRI scanner	Possible		No	Yes	Yes	
Lithotripsy		Yes	Yes	Yes	Yes	
RF Ablation	Yes	Yes	No	No		Yes
ECT	No	Yes	Yes	Yes		Yes
TENS	No	Yes	No	Yes		Yes
Radiation Therapy		Yes	No	No	No	
ECT generally safe						
Diagnostic Radiation	No		No	No	No	
ESWL	Yes		No	No	No	

ESWL synchronize to EKG, Δ DDD to DOO



For Elective Surgery

Consult ICD Service/Clinic for Device Interrogation and Programming

Program to Asynchronous mode

Magnet activated testing/programming turned OFF

Adaptive rate pacing OFF

Tachycardia sensing for ICD OFF

Device needs to be tested/reprogrammed after surgery

Do not place cautery grounding pad so that pacer & leads are located between bovie and grounding pad

Lowest possible energy and short bursts on cautery

Monitor arterial pulse form and heart sounds to detect hemodynamic instability

Have external defibrillator- if needed locate pads ≥ 10 cm from pulse generator. Use ant-post placement. Current flow should be



For Emergent Surgery

Identify device

Contact Manufacturer, follow recommendations

Check EKG- if no pacing artifacts, place magnet over pulse generator to see if device functional.

Reprogram the device to asynchronous mode if possible. If not use magnet in the OR to do this if needed.

DO NOT place magnet on a AICD unless shocks or antitachycardia pacing in response to EMI is destabilizing

Device still needs to be checked, reprogrammed post- procedure.

What affects pacing threshold ?

↑ Pacing threshold

Bretyllium, sotalol, possibly lidocaine, B blockers, procainamide, quinidine, verapamil

Hyperkalemia, acidosis/alkalosis, hypoxemia, cardioversion/defibrillation

↓ Pacing threshold

Atropine, catecholamines, glucocorticoids, myxedema, hyperglycemia

No proven effect- amiodarone, anesthetics



Medtronic, Inc.
Implanted Device Identification



I have a Jewel Plus defibrillator implanted.

In emergency, call 911. Perform CPR. Device's Therapeutic shocks may be felt but will not be harmful. EMT: Place the Evt. Defibrillator paddles 15 cm away from ICD. If ineffective, switch positions to posterior-anterior. Placing a magnet over the ICD will prevent delivery of tachy therapies but will not alter brady pacing.

Please contact my doctor(s):

Margaret Smith, M.D.

(612) 754-0549

Jane Johnson, M.D.

(612) 871-2345

My device may
trigger metal
detection systems.



Medtronic, Inc.
Implanted Device Identification



I have a Thera i DR pacemaker implanted.

In case of a medical question or emergency,
please contact my doctor(s):

Margaret Smith, M.D.

(612) 754-0549

Jane Johnson, M.D.

(612) 871-2345

My name:

DOE, JOHN
123 MAIN ST
HOMETOWN MN 55555

My defibrillator system model, serial numbers,
and implant dates:

72208	PCV010101H	15 NOV 1996
6936110	TAT020202V	15 NOV 1996

Medtronic Patient Toll-Free Number: 1-800-551-5544

© Medtronic 1997

<http://www.medtronic.com>

LC9600711004

My name:

DOE, JANE
1234 MAIN ST
HOMETOWN MN 55440

My pacing system model, serial numbers,
and implant dates:

79601B	P08200123H	15 FEB 1997
553445	LDG012345V	15 FEB 1997
503458	LDF023456V	15 FEB 1997

Medtronic Patient Toll-Free Number: 1-800-551-5544

© Medtronic 1997

LC9600711004

Transcutaneous Pacing

Simultaneous atrial and ventricular capture

Threshold for capture 35 – 70 mA, pulse width 40 ms (35 to 70 J)

Does not always work- obese, COPD



Esophageal Pacing



Only atrial capture is reliable

Unsuitable for advanced Hb or Afib

Advance catheter 35 to 45 cm from lips

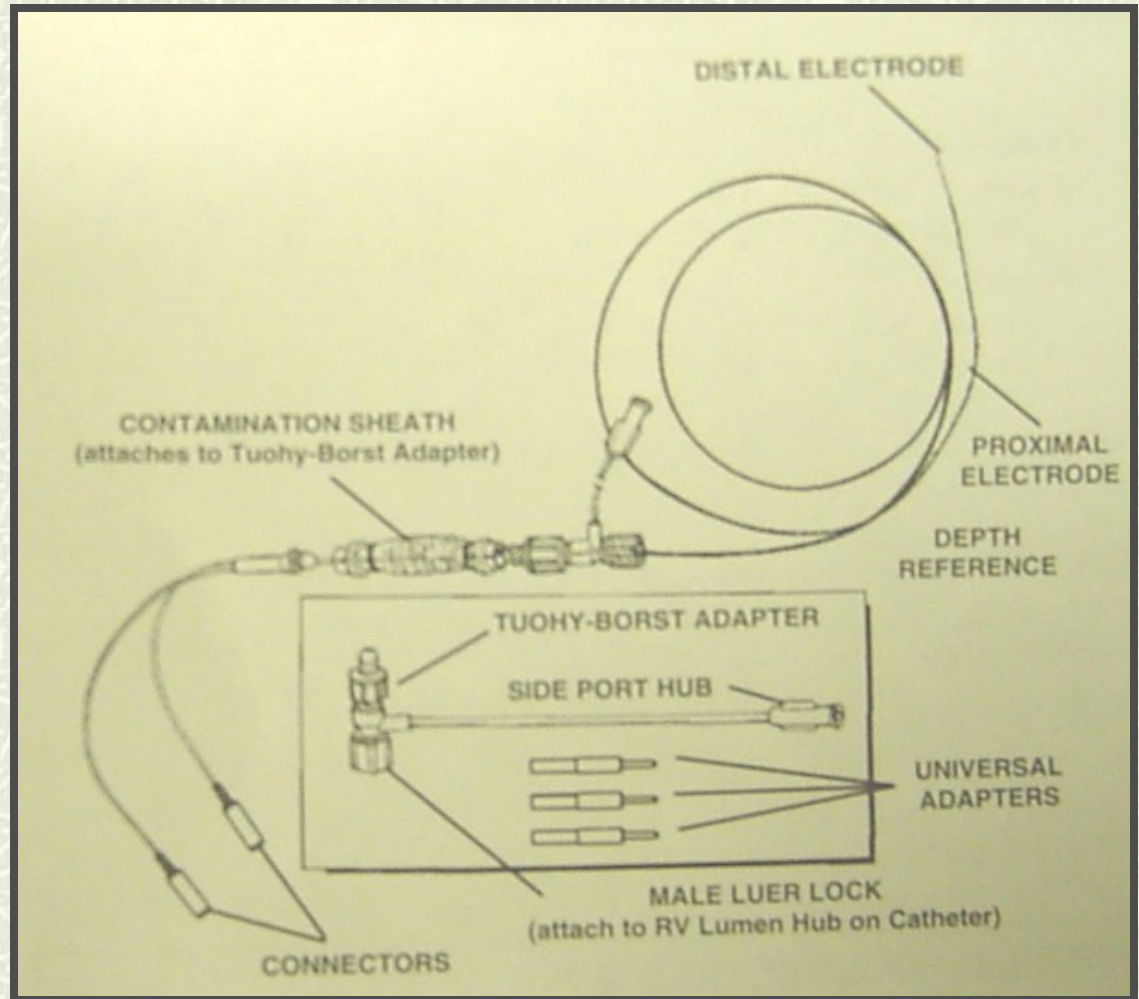
Usually capture at 15 to 25 mA with pulse width of 10 ms



Transvenous pacing

Balloon tipped catheter

Wire which can go through Paceport Swan or through VIP port of standard PA catheter





Surface Lead II



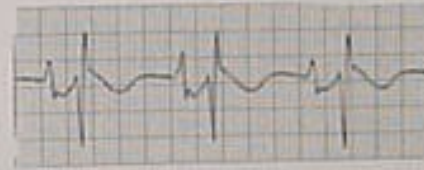
Superior Vena Cava



High Right Atrium



Mid Right Atrium



Low Right Atrium



Right Ventricle
(Good Contact)

